

Status Report of the Venera-D Joint Science Definition Team

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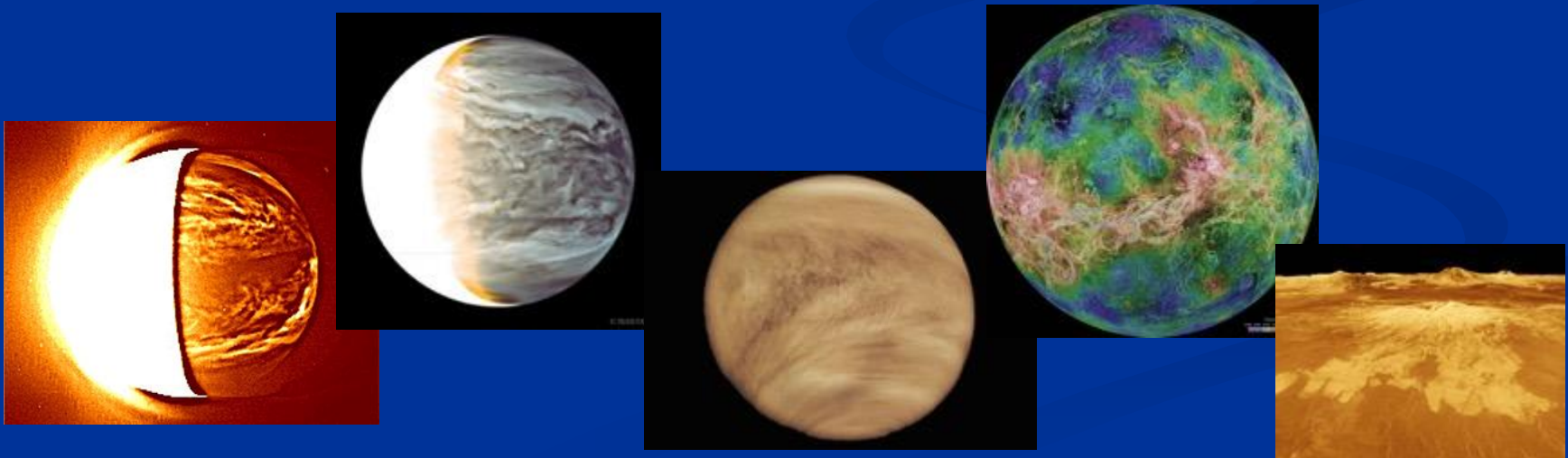
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Overview

- **Venera-D JSDT Phase 2 Tasks of the**
- **Venera-D Mission Concept Architecture**
- **Status briefing to the Directors (Jim Green and Lev Zelenyi)—2 October 2017**
- **Moscow Venus Modeling Workshop**
- **Schedule of JSDT Activities**

Venera-D Mission Concept Study Phase 2

GOAL: Definition of a focused Venera-D mission architecture concept based on the January 2017 JSDT report, including a prioritized list of potentially contributed elements and down-select options.

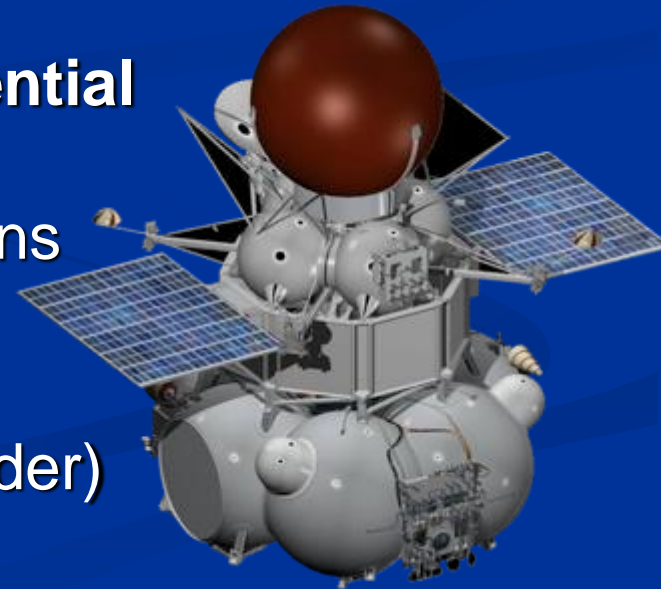


Summary of Venera-D Phase 2 Tasks

Task	Status
<i>MISSION CONCEPT</i>	Assessment ongoing and to continue work in 2018
<i>MISSION OPERATIONS</i>	Assessment ongoing and to continue work in 2018
<i>CONTRIBUTED ELEMENT ACCOMMODATION</i>	Assessment ongoing and to continue work in 2018
<i>RISK ASSESSMENT</i>	To be worked in 2018
<i>MISSION CONCEPT SCIENCE REFINEMENT</i>	Workshop at GRC completed, Moscow Workshop in October 2017
<i>LANDING SITE IDENTIFICATON</i>	Input from Phase 1 study and Moscow Workshop
<i>PAYLOAD REFINEMENT</i>	Assessment ongoing and to continue work in 2018
<i>POTENTIAL CONTRIBUTED ELEMENT(S)</i>	Status reported to the Directors; continued assessment of key development milestones ongoing
<i>FINAL REPORT</i>	Outlining and assignments to be focus of March JSDT meeting

Venera-D Concept Architecture: Mission Elements

- **Baseline:**
 - Orbiter: Polar 24 hour orbit with a lifetime greater than 3 years—Can trade orbiter period for communication with other elements
 - Lander (VEGA-type, updated) 2+ hours on the surface (one hour to conduct baseline science and one hour of margin)
- **Other components discussed as potential augmentations:**
 - Free flying aerial platform and balloons
 - Sub-satellite
 - Small long-lived stations (also considered as an instrument on the lander)



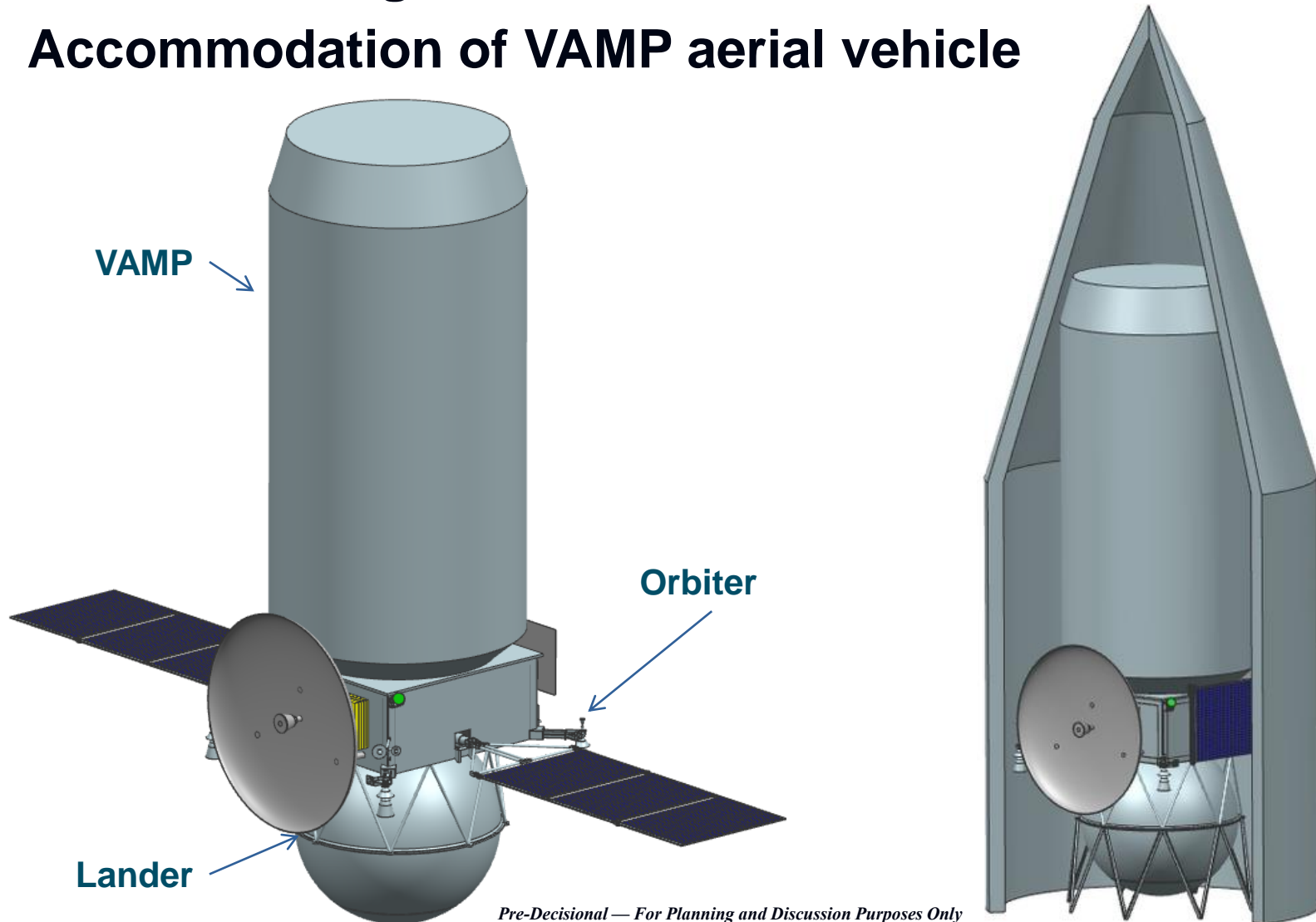
Proposed Architectural Options for Assessment

	Maximum Capability Mission	Intermediate Capability Mission	Moderate Capability Mission
Flight Elements	Baseline Orbiter and Lander; Aerial Platform; Small long-lived station	Baseline Orbiter and Lander; Aerial Platform	Baseline Orbiter and Lander
Science Enabled	Comprehensive Atmosphere and Surface Science	Core science objectives with enhanced atmospheric science	Core science objectives (High and Medium priority)
Challenges	--Large number of flight elements and deployments resulting in potentially high technical and scientific risk; --Integration, validation, testing, and operation of multiple flight elements	Integration, validation, testing, and operation of multiple flight elements	Integration, validation, testing, and operation of flight system
Potential Contribution Options	DSN Support; Instrument(s); Flight Element; Test facilities	DSN support; Instrument(s); Flight Element; Test facilities	DSN support; Instrument(s); Test facilities

Focus of work in 2017

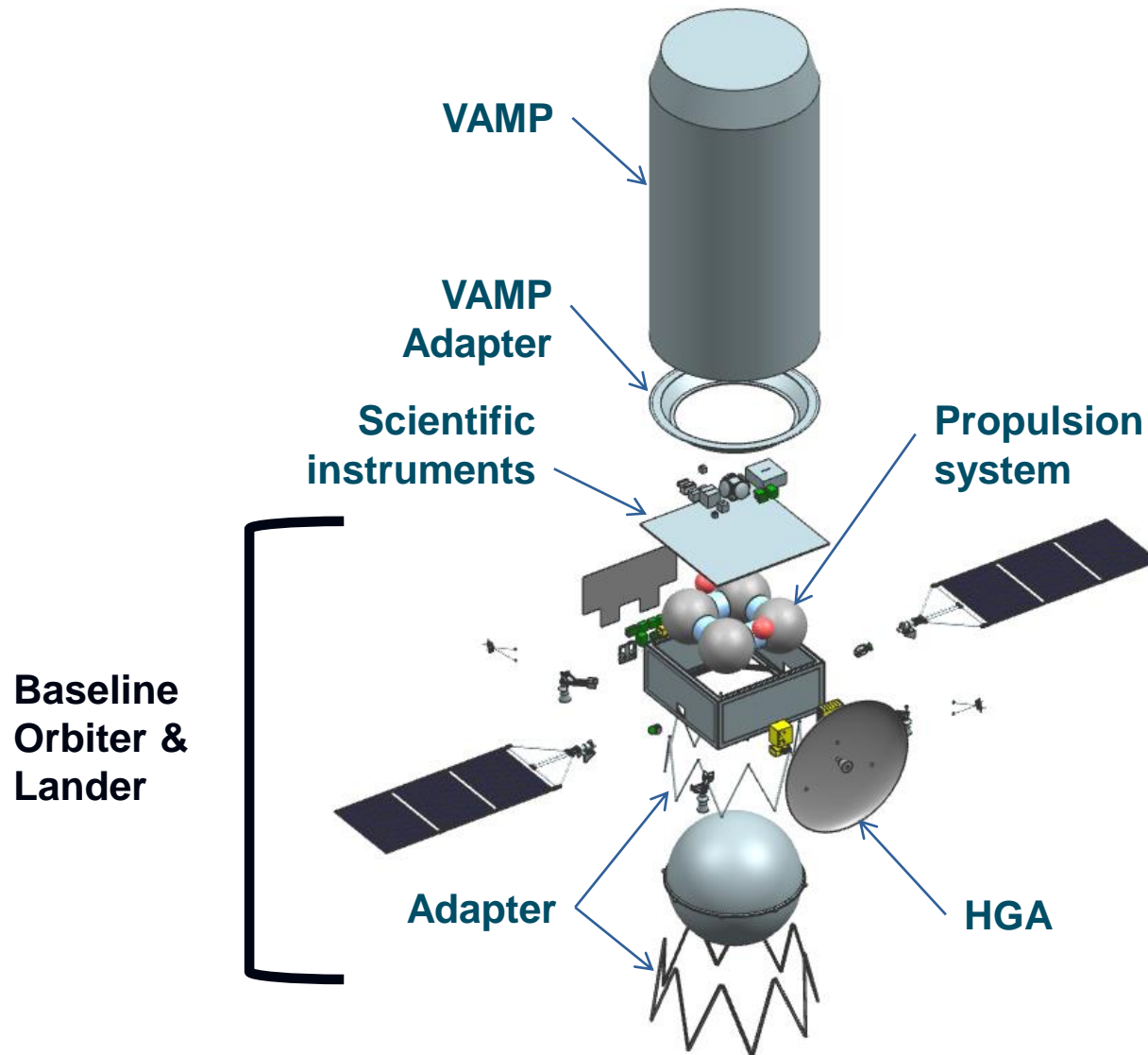
Venera-D Concept Architecture: General Spacecraft Configuration

- Launch on Angara 5 in the 2026 to 2031 time frame
- Accommodation of VAMP aerial vehicle



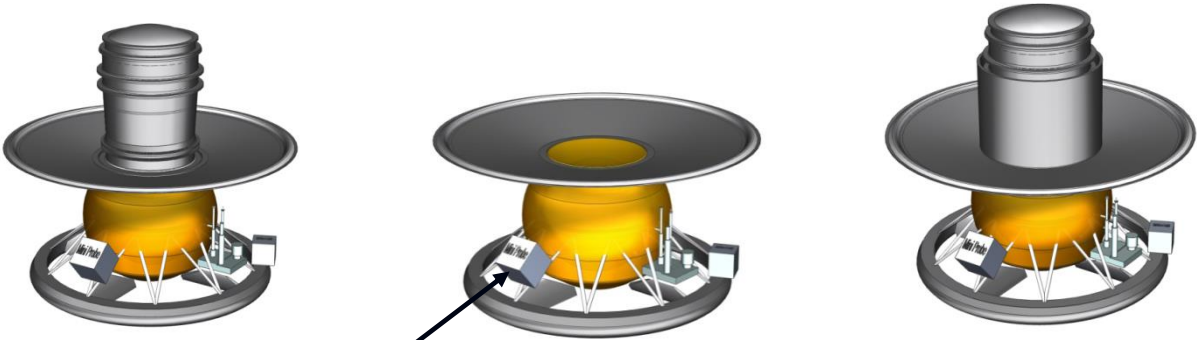
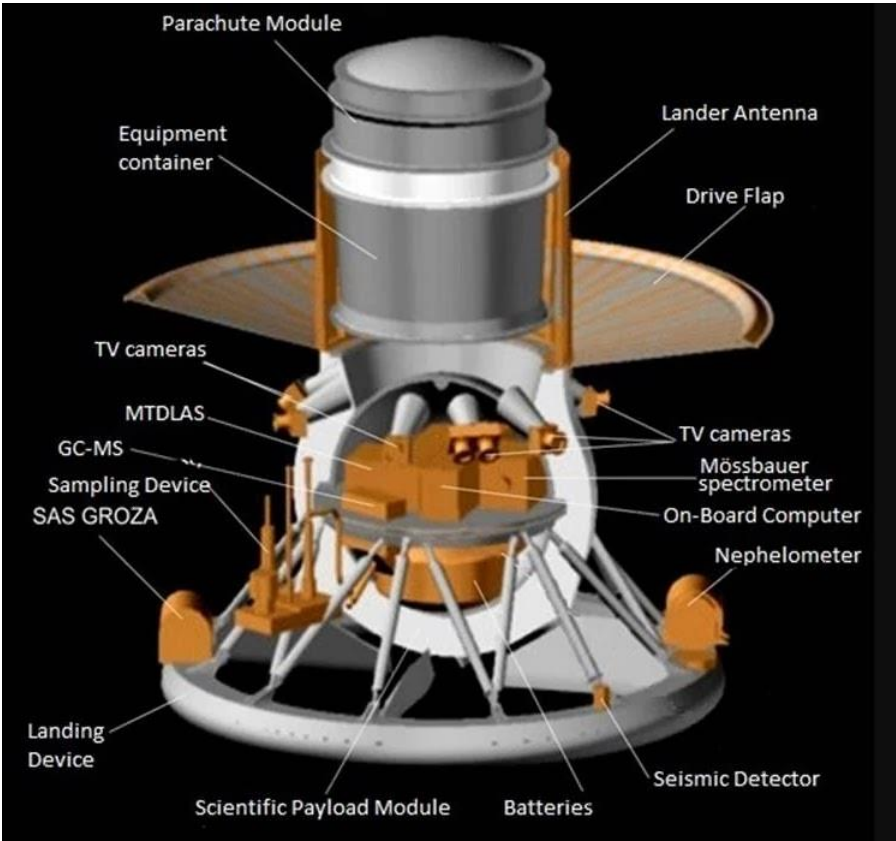
Pre-Decisional — For Planning and Discussion Purposes Only

Venera-D Concept Architecture: Spacecraft Configuration



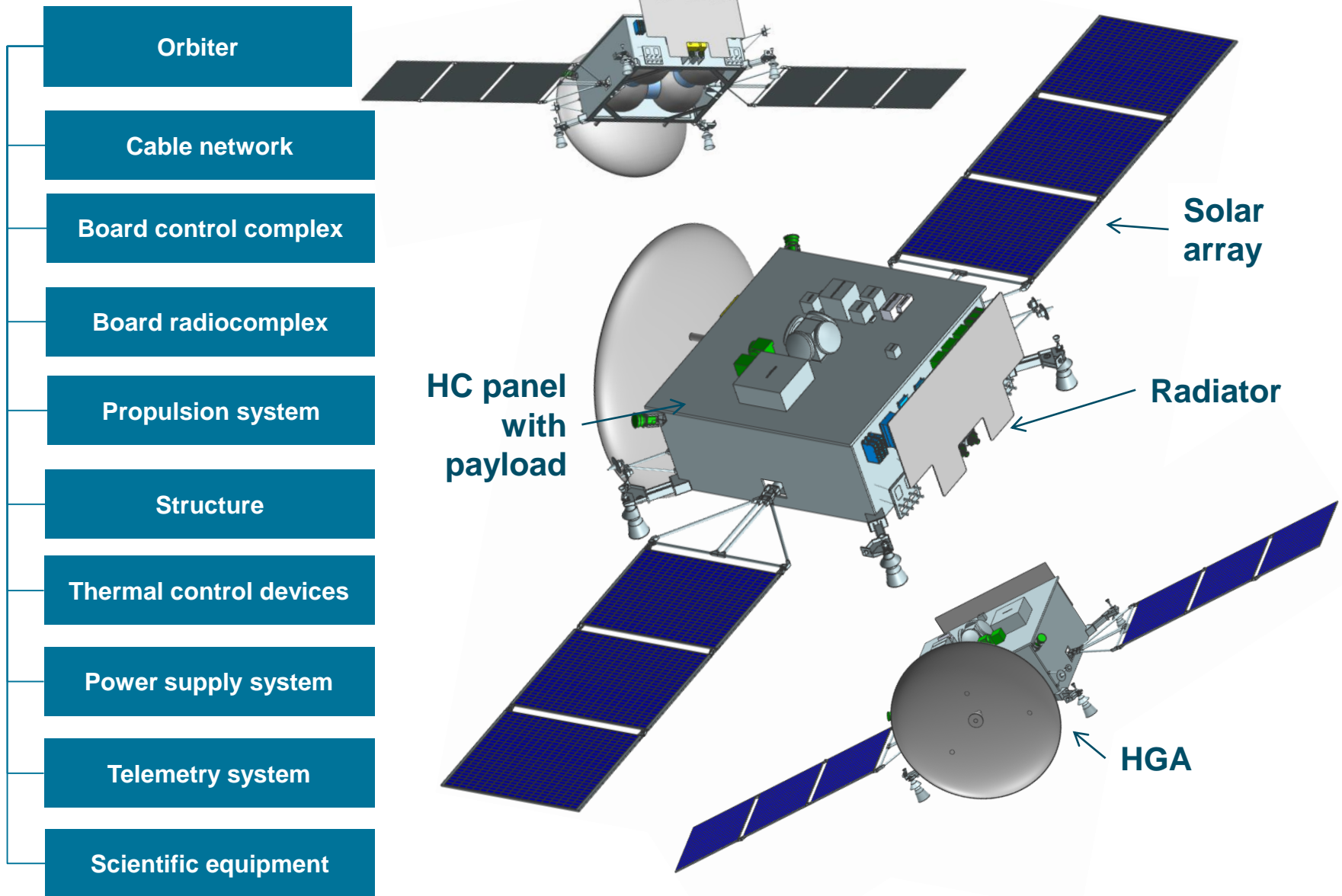
Venera-D Concept Architecture: Lander Components

- Landing module (ПМ)
- Onboard cable network
- Onboard control complex
- Onboard radio complex
- Structure
- Thermal control tools
- Power supply system
- Telemetric system
- Scientific equipment

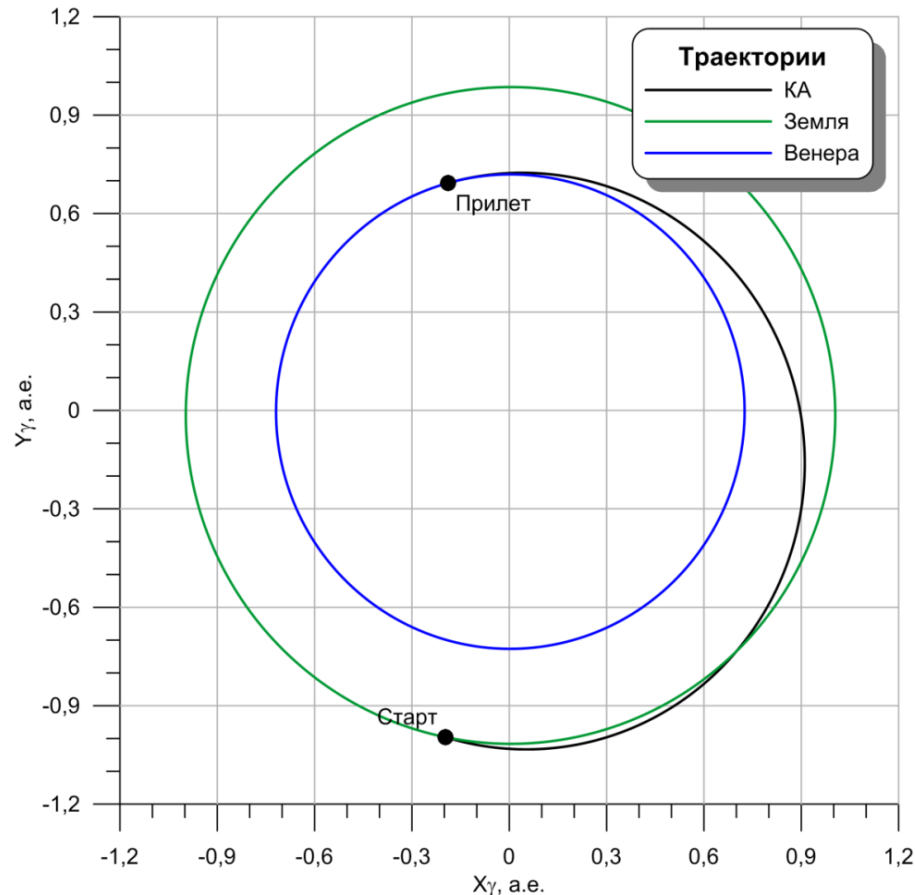


Long-lived station

Venera-D Concept Architecture: Orbiter Components



Venera-D Concept Architecture: Delivery of Flight System to Venus



- 1) Injection of SC into departure trajectory in 2026 (alternative launch dates – 2028, 2029, 2031); transfer to transit Earth-Venus trajectory using a booster; separation of booster and adapter.
- 2) Interplanetary stage of 4 month duration including trajectory corrections and finishing at the arrival at Venus.
- 3) Separation of the lander from SC 2 days before arrival at Venus.
- 4) Maneuvering of SC to prevent the orbiter from entering the Venus atmosphere.
- 5) Maneuvering the orbiter to inject it into a 24 hour elliptical orbit; separation of VAMP, other scientific separable equipment; fulfillment of scientific program:
 - Orbiter duration of 3 years after injection into orbit;
 - Lander duration of 3 hours after landing.

Status Briefing to the Directors

- Meeting took place at IKI on 2 October 2017
- Briefing Topics:
 - Overview of NASA Venus activities
 - Venera-D architecture
 - Report on NASA aerial platform study
 - Report on Venus Workshops
 - Discussion of work to go
- Key Direction provided:

An architecture has been identified that provides the maximum possible capability. To constrain the resource trade space, the JSDT should focus on a core architecture consisting of an orbiter and lander. The lander should include an attached long-lived station.

Moscow Modeling Workshop

- **The Workshop took place from 5-7 October 2017 at IKI**
- **Workshop topics (see Backup for full agenda):**
 - **General Circulation Models**
 - **Results from Akatsuki**
 - **Chemistry and Clouds**
 - **Aerial platforms**
 - **Plasma**
 - **Interior, surface, and landing sites**
 - **Mission architecture**
 - **Laboratory experiments**

Moscow Modeling Workshop

- **Thanks to NASA invited participants!**

Michael Way (GISS)

Amanda Brecht (ARC)

Thomas Navarro (UCLA)

Lori Glaze (GSFC)

Allan Treiman (LPI)

Kevin McGouldrick (LASP)

Glyn Collinson (GSFC)

Sara Port (U. of Ark.)

- **Extra thanks to our early career recording secretaries!**

Dmitry Gorinov (IKI)

Amanda Brecht (ARC)

Mikhail Luginin (IKI)

Sara Port (U. of Ark.)

Evgeniy Guseva (GEOKHI)

Gly Collinson (GSFC)

Kevin McGouldrick (LASP)

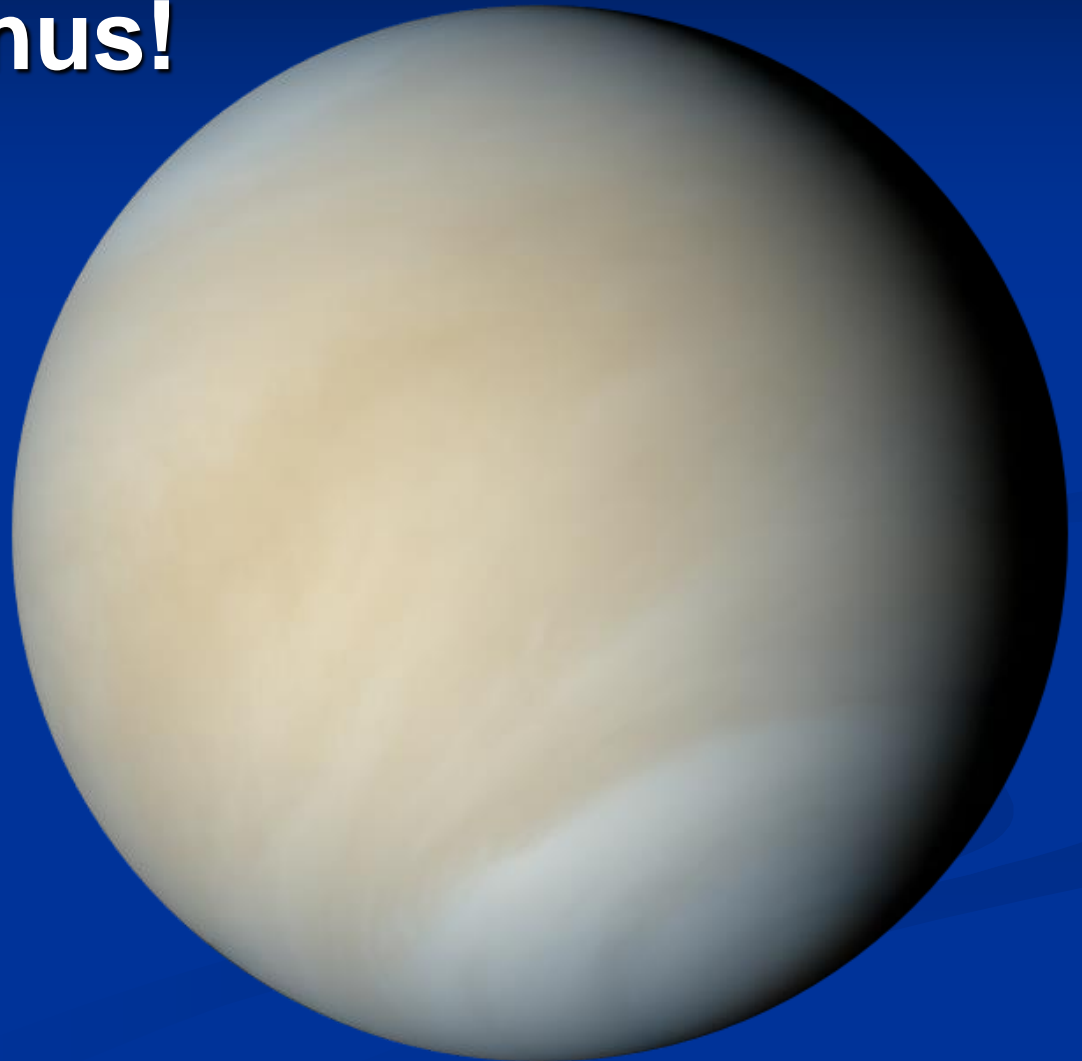
- **Notes from the proceedings of the workshop are under review and will be made available**

Venera-D Mission Concept Study Phase 2 Tasks—High-Level Schedule

14 to 16 March 2017	JSDT meeting to finalize Phase 2 plan and protocol between IKI and the Lavochkin Association	X
2 October 2017	Briefing to Directors	X
March/April 2018	JSDT meeting (Moscow)—Outline of report and writing assignments	
Summer 2018	Briefing to Directors	
October 2018	JSDT meeting (Moscow)—Review of draft of report	
January 2019	Deliver Report to Directors	

- **Full JSDT telecons every two weeks**
- **Technology and Engineering telecons every 2 weeks**

Together to Venus!



Backup

VENERA-D Venus Modeling Workshop

5/10/2017

10:00 *Welcome*

Lev Zeleny, James Green, Sergey Lemeshevskii

11:00 Ludmila Zasova, David Senske, and JSDT, *Status of Venera-D*

11:20 T. Kremic, *Briefing from VEXAG Venus Modeling Workshop*

11:35 Coffee break

General circulation models

11:50 Alexander Rodin *Gas dynamics general circulation model of the Venus atmosphere*

12:20 Sebastien Lebonnois *Behavior of Venus planetary boundary layer as predicted by the Venus GCM*

12:40 Josette Bellan *Usefulness Of Supercritical Fluid Modeling To Understanding The Venus Lower Atmosphere And Boundary Layer*
(poster)

12:45 Amanda Brecht *the Latest on the Venus Thermospheric General Circulation Model: Capabilities and Simulations*

13:10 Lunch

Akatsuki

14:00 Takehiko Satoh *New Views of Venus as Obtained From Akatsuki*

14:30 Yeon Joo Lee *Venus seen from the UV imager onboard Akatsuki*

15:00 Sanjay Limaye *Multispectral Day and Night Cloud Morphology of Venus from Akatsuki Cameras*

Chemistry, clouds

15:20 Vladimir Krasnopolsky *Modeling of Chemical Composition in the Lower and Middle Atmospheres of Venus*

15:40 Franklin Mills *Simulations of Vertical Profiles of SO and SO₂ in Venus' Mesosphere*

16:00 Kevin McGouldrick *Microphysical Modeling of the Sulfuric Acid Venus Cloud System*

16:30 Coffee break

16:50 Cristopher Parkinson *on Understanding the Nature and Variation of the Venusian Middle Atmosphere via Observations and Numerical Modeling of Key Tracer Species*

17:10 Sara Port *Metal Sulfides and their Relation with Gaseous Sulfur on Venus*

17:40 Discussion of results of the 1st day sessions

6/10/2017

Aerial platforms

10:00 James Cutts *Venus Aerial Platforms and Engineering and Scientific Modeling Needs*

10:30 Siddharth Krishnamoorthy *Infrasound Detection from Balloons – Perspectives from Simulations*

10:50 Sebastien Lebonnois, *Exploring Balloon Trajectories in a Modeled Venus Atmosphere* (poster)

10:55 Alexander Rodin, *LIDAR spectroscopic sounding of the ambient atmosphere and cloud layer onboard Venus atmospheric platform* (poster).

11:00 Coffee Break

11:20 Thomas Navarro *Large Stationary Gravity Waves: A Game Changer for Venus' Science*

Posters:

11:50 Igor Khatuntsev *Cloud level circulation according to UV and near-IR VMC imaging onboard Venus Express*

11:55 Dmitry Gorinov *Circulation of Venusian atmosphere at 95-100 km from apparent motions of 1.27 μm O₂ nightglow*

12:00 Ludmila Zasova *Effects of surface topography in atmosphere from middle clouds to mesopause*

12:05 Vladimir Gubenko *High-Latitude Zonal Winds In The Venus's Atmosphere From Venera-15 And -16 Radio Occultation Data*

5. Plasma

12:10 Glyn Collinson *Mysteries of Atmospheric Escape and Evolution at Venus*

12:40 Lev Zeleny, A. Petrukovich, **O. Vaisberg** *Solar wind interaction with Venus – implication to atmosphere and lessons from Mars*

13:00 Anatoly Gavrik *Radio-Occultation Measurements Of Plasma Layers In Venusian Ionosphere* (poster)

13:05 Lunch

Interior, surface, landing sites

14:00 Philippe Lognonné, *Venus Seismic Interior-Atmosphere Coupling: Theory and Orbital Perspectives*

14:30 Tamara Gudkova, *Interior Structure Models Of Venus* (poster)

14:35 Lori Glaze *Scientific Rationale For Selecting Landing Sites On Venus: So Many Choices, So Few Opportunities!*

15:05 Richard Ernst *Venera-D Landing Site Selection Based on Detailed Geological Mapping Using Magellan Radar Images*

15:25 Piero D'Incecco. *Imdr Regio as the landing site of the Venera-D mission: a geologic perspective* (poster)

15:30 Thanasis Economou *Venus Surface Elemental and Mineralogical Composition*

16:00 Mikhail Ivanov *Estimates Of The Frequency Distribution Of Short-Baseline (1-3 m) Slopes For Different Terrains On Venus Using Terrestrial Analogs*

16:30 Coffee break

16:45 Allan Treiman *Venus' Radar-Bright Highlands: Different Causes at Low- and High-Latitudes*

17:15 Michael Way *Modeling Venus through Time and its Implications for the Habitable Zone*

17:35 Splinter meeting 1. Atmospheric platforms, priority of scientific goals, experimental capability, VAMP, balloons.

18:35 Discussion of the results of the 2nd day

19:00 Adjourn

7/10/2017

Mission architecture

10:00 Sergey Lemeshevskii *"To Venus together": international project implementation on Venus planet research*

10:20 Oleg Grafodatskii *"Towards Venus together": The preliminary architecture of "Venus-D" mission on the basis of joint scientific program proposals of Roscosmos-NASA Joint Study Group on Venus researches*

10:40 Natan Eismont *Venera-D Project: Scenario and Trajectory Design Problems*

11:00 Alexandr Kosov *Venera D. Radio Link Lander-Orbiter* (poster)

Experiments

11:05 V. Mikhalsky, Mikhail Gerasimov *A Prototype of the Soil Sampling System for the Venera-D*

11:15 Maxim Litvak *Active gamma ray spectrometer proposed for future Venus surface ugene*

11:25 Coffee Break

11:45 Eugene Maksimov *Possible application of Raman Spectroscopy for future space missions*

11:50 Vladimir Gromov *Radiometer for Thermal Sounding of Low Atmosphere and Sulfur Compound Detection*

12:00 Eugene Ustinov. *Cloud Internal Field Radiometer (CIFR)*

12:10 Leonid Ksanfomality *Lightning on Venus – unsolved puzzle*

12:20 Discussion of the results of the 2nd day

13:00 Lunch

14:00 Discussion of workshop report

15:00 Splinter meeting 2: GCMs, Dynamics, gravity waves, superrotation, boundary layer, experiments, preferable orbits etc.

16:00 Splinter meeting 3. Architecture, landing sites, orbits, geology, geochemistry, evolution, interior.

18:00 Adjourn